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Effectiveness of existing noise barriers: comparison between vegetation, concrete hollow block, and panel concrete

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Abstract

Noise barrier is used to shield receivers from noise especially road traffic noise. In Malaysia, there is lack of literature regarding noise barriers including the effectiveness of noise barrier that has been erected. This study investigates the effectiveness of existing noise barriers; vegetation, concrete hollow block and panel concrete at three urban residential areas in Klang Valley region. Insertion loss is used to identify the effectiveness of selected noise barriers. The finding indicates that panel concrete provides consistent insertion loss and exceed the minimum value of effective noise barrier followed by concrete hollow block and vegetation.

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Keywords: noise barrier; vegetation; concrete hollow block; panel concret;, insertion loss

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1. Introduction

Some noise reduction measures that are possible on existing roads including erect noise barriers and managing traffic. Noise barriers are solid obstruction built between the highway and residential areas. Noise barrier can be built out of wood, concrete, masonry, metal and transparent materials [1]. Noise barrier perform at its best if long enough and high enough to block the view of the road. However, the function of the noise barrier is only as noise reducer but not completely block the sound annoyance [1].

In order to evaluate the effectiveness of the noise barrier, insertion loss is used. Insertion loss is defined as differences between the measured sound pressure levels behind existing barriers and without barriers [2]. However, there is still a lack of research in noise barrier in Malaysia. Little attention has been carried out to the effectiveness of noise barrier that has been built. Thus this study was conducted to determine the effectiveness of noise barriers in urban residential areas in Klang Valley Malaysia in hoping to bridge the gap in the literature.

2. Material and method

The present study of effectiveness of noise barriers were conducted in urban residential areas in the city of Klang Valley, Malaysia. Three types of noise barriers were selected including vegetation, concrete hollow block, and panel concrete that were located adjacent Sungai Besi Highway, DUKE Highway, and KESAS Highway respectively. Noise level in 'A' weighting network was measured using the Sound Level Meter (SLM) which complies with the International Electrotechnical Commissioning (IEC) 61672 Class 1 standard. The SLM used was Blue Solo 01 model that has been manufactured by 01dB-Metravib.

Procedure for field measurements to determine insertion loss was based on the ISO 10847:1997 [3] and ANSI S12.18-1994 [4]. To determine the insertion loss of the barriers, indirect BEFORE method at an equivalent site were used. The method requires noise measurement at a site with a barrier to determine AFTER noise levels and another sets of measurements at an equivalent site without the presence of the barrier to determine the equivalent BEFORE levels. The BEFORE and AFTER sets of noise measurement for the indirect BEFORE method should be measured simultaneously to ensure the equivalent conditions of traffic and meteorology. However, it is hard to find an ideal equivalent site. Good engineering judgment should be used on whether or not the adjacent site without barrier is equivalent enough for ground surface or potential influencing factors.

The noise measurements were carried out for five days with two hours of monitoring during peak time (0700 to 0900, 1200 to 1400 and 1700 to 1900) as well as off peak time (2300 to 0100). These measurements were conducted for each sampling location with three sets of measurements. The data of number of vehicles and the composition of traffic were recorded for every 15 minutes.

The noise monitoring was carried out from 14 June 2011 until 17 July 2011. The meter was held 1.5 meter above the ground surface on the highway shoulder at a distance of 3 m from the pavement edge for both BEFORE and AFTER sets. All noise monitoring experiments were carried out under ideal meteorological condition with relative humidity, temperature and wind speed of sites varied from 76% to 93%, 26 to 29°C and 0 to 0.7 m/s.

3. Results and discussion

Fig. 1 illustrates insertion loss recorded during weekdays and weekends for different types of noise barriers.

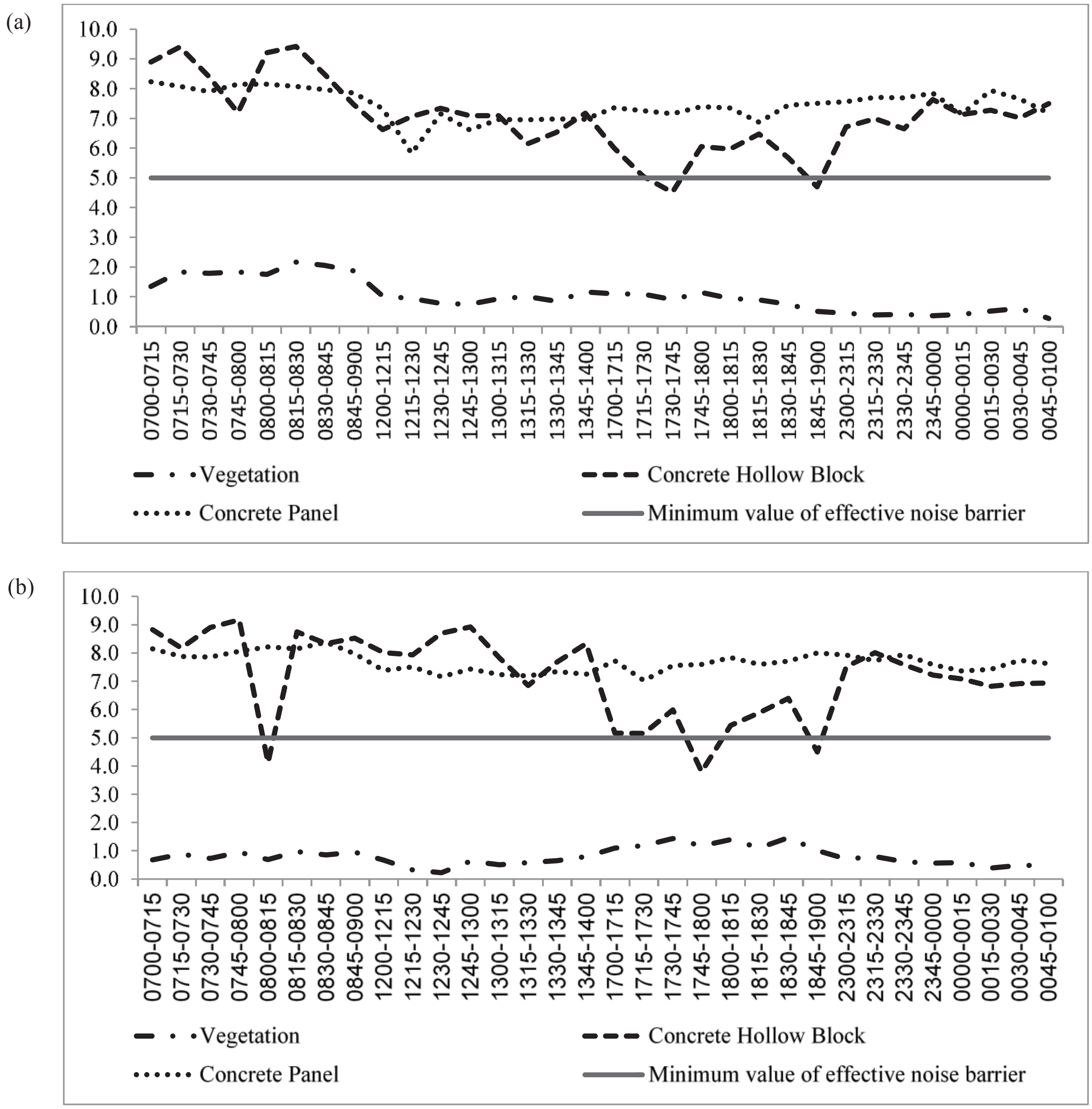

Fig.1. Average of insertion loss of every 15 minutes of measurements of three different type of noise barriers during (a) weekdays (b) weekends

Fig. 1 shows an average of insertion loss of three type of noise barriers including vegetation, concrete hollow blocks and concrete panel. Effective noise barriers typically reduces noise levels by 5 to 10 dB(A) and usually depend on its dimensions and location relative to the source and receiver positions [1,5,6]. Jorge stated that environmental noise barriers reduced A-weighted noise levels depending on their design and height [7]. If the barrier surface density exceeds 20 kg/m^2, a reduction of 5 dB(A) can be achieved by having a barrier tall enough to break the line of sight from the road to the receiver and an additional 1.5 dB(A) reduction can be achieved for each additional meter of height [7].

During weekdays, insertion loss recorded by vegetation ranged between 0.3 and 2.2 dB(A). The concrete hollow blocks recorded the widest range of insertion loss ranged between 4.5 and 9.4 dB(A). The precast concrete panels showed a constant value of insertion loss that exceeded the minimum value of insertion loss in the range of 5.8 to 8.2

dB(A) for all measurements. The noise barriers of vegetation, concrete hollow blocks, and precast concrete panel recorded insertion loss ranged between 0.2 and 1.5 dB(A), 3.8 and 9.2 dB(A) and 7.0 and 8.4 dB(A) respectively during weekends.

Both weekdays and weekends show the same trend of insertion loss by each type of noise barriers. Vegetation recorded the lowest insertion loss in this study. Even though vegetation has been proposed as a natural material to reduce outdoor noise level [8], however in this study the vegetation is not high and dense enough to shield the receiver effectively from highway noise. According to Fang [9], important factors for vegetation to act as noise reduction include visibility, width, height and length of the vegetation. It should be noted that at least 30 metres width of vegetation along the noise source could provide great noise reduction [9]. As in this study, the two rows of Bunga Tanjung (mimusops elengi) with height of 5 to 15 metres and width of 0.5 metres were planted next to the highway shoulder for 100 metres along the highway. It is clearly that the shielding provided by the vegetation barrier at the studied site as was not enough because its width and dense was insufficient to protect the residential area next to the highway from the high traffic noise level. The insertion loss for this type of noise barrier is therefore lower as compared to the other type of noise barriers.

The concrete hollow blocks recorded 2 data of insertion loss during weekdays and 3 data during weekends; which were below the minimum value of effective noise barrier. It means that concrete hollow blocks provided partially effective noise barrier to protect receivers from traffic noise pollution. However, concrete panel provided stable and sufficient insertion loss throughout measurement period. Attenuation of noise can be achieved due to refraction, reflection, scattering and absorption effect9. According to Hothersall, D.C et al [10], the effect of vertical barrier with reflecting surface can be significant for receivers in reducing the noise. Therefore, refraction and reflection of noise waves by the flat and solid surface of concrete hollow blocks that faced the highway helps to reduce the noise level at the AFTER set. That is most probably the reason of high insertion loss of concrete hollow block noise barriers. The concrete panel recorded the most effective noise barrier with substantially stable insertion loss recorded during measurement session. It was also due to diffraction and refraction of noise waves by flat and solid surface of concrete hollow blocks that faced the highway.

Both concrete masonry hollow blocks and concrete panels could be categorized as noise absorptive and reflective noise barrier (LLM) [11]. The interior of the concrete hollow blocks and precast concrete panels will generally include cavities for the purpose of achieving sound absorbing goals. These cavities will have resonant frequencies with the overall blocks and panels. This situation can reduce road traffic noise from entering residential areas. Therefore, concrete hollow blocks and precast concrete panels noise barriers provide sufficient insertion loss to the receivers. However, the precast concrete panels perform a consistent insertion loss for all measurement periods compared to the concrete hollow blocks because other than depending on the cavities to reduce noise, concrete hollow blocks also need to rely on wall joint between the blocks [12]. As the construction of concrete hollow blocks noise barrier includes a lot of joint between blocks as compared to the precast concrete panels, the sound leakage probably occurs between the joint and reduces the insertion loss of concrete hollow block noise barrier.

4. Conclusion

Vegetation recorded the lowest insertion loss in this study. The concrete hollow blocks are fairly effective as noise barrier to protect receivers from traffic noise pollution. Moreover, the concrete panel has stable and sufficient insertion loss recorded during measurement session. This was also due to diffraction and refraction of noise waves by the flat and solid surface of concrete hollow blocks facing the highway. The cavities inside both concrete hollow block and concrete panel noise barriers help to absorb the noise from traffic on the highway. The precast concrete panels perform a consistent insertion loss throughout all measurement periods as compared to the concrete hollow blocks. This can be correlated to the fact that the concrete hollow blocks also need to rely on wall joint between the blocks; rather than depending only on the cavities to reduce the noise. As the construction of concrete hollow blocks noise barrier includes a lot of joint between blocks as compared to the precast concrete panels, there is possibility that the sound leakage occurs between the joint and reduces the insertion loss of concrete hollow block noise barrier.

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